Massachusetts Department of ENVIRONMENTAL PROTECTION

f a c t s h e e t

Ground Source Heat Pumps (GSHP) - Geothermal & Ground Water Heat Pump Wells

Authorization to Install & Operate

What is a Ground Source Heat Pump (GSHP)?

Ground Source Heat Pump (GSHP) systems are heating systems that exchange heat from an underground source in either a heating or a cooling system. The wells that are typically associated with GSHP systems are regulated by MassDEP under the Groundwater Discharge Program (314 CMR 5.00), the Underground Injection Control (UIC) Program (310 CMR 27.00) and/or the Water Management Act (310 CMR 36).

These systems take advantage of the earth's relatively constant temperatures just below its surface (a range of 45° to 65°F). In the heating season, a fluid in the loop collects heat from the earth and transfers that heat to the building. The system then uses electrically driven compressors and heat exchangers to concentrate the heat and release it at a higher temperature into the building.

There are two main types of GSHP systems:

1) closed-loop systems and
2) open systems.

Variations of closed-loop systems are based on the configuration of the pipe, the type of antifreeze solution (if used) and the amount of heating and cooling required. Open systems vary according to the use and disposal of groundwater.

Closed-Loop GSHP Systems:

Closed-loop GSHP systems rely on the contained circulation of fluids through an underground loop of pipes. The loop acts as a subsurface heat exchanger, which transports the heat to or from the ground. The loop of pipe is installed either vertically in borings or horizontally in trenches. Traditional loop systems contain an antifreeze solution.

The typical closed-loop system consists of three types of loops: a subsurface loop, a refrigerant loop, and the cooling/heating distribution loop. The subsurface loop typically consists of polyethylene pipe, which is placed horizontally in a trench or vertically in a boring. This thin-walled pipe acts as a heat exchanger, which transfers heat from or to the ground. Antifreeze fluids (if used) inside the pipe are circulated to the heat exchanger of an indoor heat pump where it releases heat to the refrigerant.

In general, the risk of groundwater contamination from closed-loop GSHP systems is very low. However, with an antifreeze fluid that is circulated through the pipes, the potential exists for a leak or rupture to occur that allows the antifreeze to escape. If the fluid is a polluting substance such as a methanol or ethylene glycol, the system owner can be liable for cleanup of the soil and/or aquifer. It is for this reason that biodegradable mixtures such as food grade propylene glycol are recommended by MassDEP (all others must be approved before use).

Another type of closed-loop system is the direct exchange (DX) heat pump system. In a DX system, the underground loop contains the refrigerant. The direct exchange loop typically operates with copper pipes that are placed underground. The refrigerant is circulated directly through the subsurface. A DX system requires several times the amount of refrigerant normally used, and any holes in the copper tubing would cause a loss of the refrigerant.

Open GSHP Systems:

Open GSHP systems typically depend on the circulation of groundwater from a supply well to a discharge area. The source for heat (groundwater) is moved from the ground to the heat pump in the building; then the water is disposed of by surface or subsurface methods.

What are the Regulatory Requirements for GSHP Systems?

MassDEP does not intend to restrict the use of GSHP systems, but rather desires to promote a safe handling of our natural resources for the benefit of everyone. This can be done by avoiding unnecessary risks of potential contamination and by paying close attention to possible groundwater overuse situations.

UIC Program Requirements:

The federal Underground Injection Control (UIC) Program regulates every injection of fluid into the subsurface. For the purposes of the UIC Program the term "injection" applies to any subsurface emplacement of fluids regardless of whether or not the "injection" requires the application of pressure or not. The term "fluid" is defined as any liquid, gas or semi-solid that can be made to flow.

Subsurface or ground surface discharges for open GSHP systems; and wells or trenches used for closed-loop GSHP systems; are classified as Class V injection wells by the U.S. EPA and the MassDEP UIC Program. The only exceptions would be for open GSHP system discharges to a surface water feature or to a stormwater system. If installed, operated, and decommissioned properly, such Class V injection wells have been determined not to pose a significant threat to the environment.

GSHP wells fall into three types within the Class V program. The three types are:

5A6	**Direct Heat Re-injection Wells** – re-inject geothermal fluids used to provide heat for large buildings or developments – not currently known to exist in Massachusetts.
5A7	**Heat Pump/Air Conditioning Return Flow Wells** – re-inject ground water used to heat or cool a building in a heat pump system
5A8	**Groundwater Aquaculture Return Flow Wells -** groundwater aquaculture return flow wells that reinject heating or cooling fluids

The owner or operator of a GSHP system must register with the MassDEP UIC Program (per 310 CMR 27.05 (2)(a) and 310 CMR 27.08 (1)) unless the GSHP system requires permitting under the MassDEP Groundwater Discharge Program (per 310 CMR 27.07 (3)(b)) or under the MassDEP National Pollutant Discharge Elimination System (NPDES) Program.

Any closed-loop GSHP system with flows in excess of 15,000 gallons per day (gpd), or any open GSHP system with subsurface discharges in excess of 15,000 gpd, must be permitted by the Groundwater Discharge Program (per 314 CMR 5.05 (5)). Any open GSHP system that discharges to a storm drain or surface water body requires a NPDES permit.

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For GSHP systems with flows of 15,000 gpd or less that do not require a NPDES permit, UIC registration form BRP WS 06e must be filed for systems that are serving four or less residential units. Form BRP WS 06c must be filed for all other groundwater or groundwater-aquaculture GSHP systems with flows of 15,000gpd or less. These forms may be obtained at http://www.mass.gov/dep/water/approvals/uic.

Prior to the construction of a GSHP system, the owner/operator/installer must submit to the UIC Program a notification of intent to construct (WS-06 application). After construction of the wells and GSHP system is complete, a UIC Program inspector may inspect the wells and system. The notification of intent to construct was required for any Class V injection well/trench first put into use after September 13, 2002 (revised UIC regulations issued) and previously existing Class V injection wells/trenches were required to be registered by January 1, 2003. However, in an effort to bring more of the existing Class V injection wells into compliance, MassDEP is currently not taking enforcement action against owners/operators who register such wells as long as the facility is otherwise conforming to applicable standards.

The following represents the minimum requirements for the construction of wells for GSHP systems:

- Wells must be sited away from potential and existing sources of contamination and from other wells;
- Open GSHP system wells shall have the same grouting and casing requirements as water supply wells;
- Closed-loop GSHP system wells also have the same grouting and casing requirements as water supply wells; but, the wells must also be constructed so that different aquifers are not interconnected by the well/borehole;
- The system shall be designed to ensure that known groundwater contamination is not spread by the direct injection of contaminated water or by the migration of contamination caused indirectly by the injection;
- At least 100 feet should separate the new well from features such as septic tanks/fields, lagoons, livestock pens, and storage tanks;
- The system shall be designed to ensure that injected water does not come to the surface or flood any subsurface structure in the immediate vicinity of the injection system;
- Wells should be designed to conserve groundwater while providing an adequate and safe supply;
- The heat pump system should have an automatic shutdown device to minimize refrigerant or oil leaks in the event of a fluid loss;
- The discharge shall not enter any open floor trench or drainage system that could also receive interior floor drainage, chemical spillage, or other wastewater that is not part of the GSHP system;
- Nontoxic, biodegradable closed-loop circulating fluids such as food grade propylene glycol are permitted for use in GSHP (other additives must be approved by MassDEP);
- Water treatment chemicals or additives containing chromium, copper, lead, zinc, or tributyl tin shall not be added to the discharge, nor shall sacrificial metals be used within the GSHP system;
- Corrosion inhibitors can be added if necessary; however they must meet the International Ground Source Heat Pump Association criteria for toxicity; and,
- Control measures may be required to reduce the total dissolved solids of waters injected from open GSHP systems.

The following information shall be included with the registration application:

- A description of the injection well, including well construction, well depth, and the injection rate and pressure;
- A description of the GSHP system, including safety features such as automatic shut-offs for fluid losses (both closed-loop and open systems); and,

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- All GSHP registrations (UIC Class 5A6, 5A7 and 5A8) shall include:

  (i) Type of non-toxic circulating medium to be used in the GSHP systems;
  (ii) Type of corrosion inhibitors to be added to GSHP system (if any);
  (iii) A description of the controls (if necessary) to reduce the total dissolved solids of waters injected into open loop systems;
  (iv) A description of the provisions to ensure that injected water does not come to the surface or flood any subsurface structure in the immediate vicinity of the injection system; and,
  (v) A description of the provisions to ensure that known groundwater contamination is not spread by the direct injection of contaminated water or by movement of contamination from one zone to another caused indirectly by the injection.

Groundwater Discharge Program Requirements:

Any GSHP system (both closed-loop and open) with flows in excess of 15, 000 gallons per day must be permitted by the Groundwater Discharge Program (per 314 CMR 5.05 (5)). Applicants must file permit form BRP WP 10 and a Certification Statement by a Massachusetts Registered Professional Engineer. The permit form and Certification Statement document may be obtained at http://www.mass.gov/dep/water/approvals/groundwaterGroundwater.

Discharge Permits are usually issued for five-year intervals. Any exemption in accordance with the provisions of 314 CMR 5.05 does not relieve the owner, operator, and installer of their responsibilities under other state regulations including, but not limited to 310 CMR 27.00 "Underground Injection Control (UIC) Program".

National Pollutant Discharge Elimination System (NPDES) Program Requirements:

The MassDEP NPDES regulations regarding the surface water discharge of GSHP wastewater require the submittal of permit application BRP WM 11. The permit form may be obtained at the following web page: http://www.mass.gov/dep/water/approvals/surffms.htm. Any ground surface discharge of GSHP wastewater that infiltrates into the ground prior to reaching a surface water feature (including lakes, ponds, rivers, streams, and wetlands) would not require a NPDES permit; however, it would be considered a UIC discharge and would therefore require registration with the UIC Program.

Stormwater Discharge Program Requirements:

Any owner, operator, or installer of a GSHP system planning to discharge to an existing stormwater drainage system must obtain prior permission from the owner of the stormwater system to determine whether the discharge meets the acceptance criteria for that system. GSHP discharge is a non-stormwater discharge and must not be contaminated in order to secure permission to discharge it to any storm drain systems regulated by the U.S. EPA NPDES Municipal Separate Storm Sewer System (MS4) Permit.

Water Management Act Program Requirements:

Withdrawals of water that, in the opinion of MassDEP, constitute a nonconsumptive use, are exempt from the need to file a registration statement or a permit application pursuant to MGL c. 21 G. or 310 CMR 36.00.

The regulations define nonconsumptive use as any use of water that results in its being discharged back into the same water source at or near the withdrawal point in substantially unimpaired quality and quantity.

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There are several types of industrial cooling processes that transfer heat from the process to water, then to the air, the water source or the ground. Non-evaporative cooling processes must demonstrate no significant water quality impacts. Evaporative cooling is considered consumptive and must be permitted because water mass is lost by the design.

Withdrawals of water for GSHP systems are generally considered nonconsumptive provided the water is returned at or near the withdrawal point and within the same water source in essentially unimpaired quality and quantity. In order for MassDEP to determine if the proposed use is considered non-consumptive, the applicant must file a Statement of Non-Consumptive Use.

The form for requesting a determination of non-consumptive use is available at: http://www.mass.gov/dep/water/approvals/wmgforms.htm

If a GSHP receives a determination of nonconsumptive use and there should be any change in the water volumes withdrawn, its use, the volume discharged, or the discharge location, the nonconsumptive use status may be withdrawn and the withdrawal may be subject to a Water Management Act Permit.

Other Regulatory Requirements:

As with other well types, only Massachusetts Certified Well Drillers are permitted to construct wells for GSHP systems. The installation and operation of GSHP systems must also comply with other applicable regulations and statutes, including but not limited to M.G. L. c. 21 & 43; the State Environmental Code, Title 5, 310 CMR 15.000; and the Massachusetts Uniform Plumbing Code, 248 CMR 2.00. In addition to state regulations and statutes, there may also be local ordinances, Board of Health regulations, and Conservation Commission requirements for discharges associated with GSHP systems.

The MassDEP wants to recognize and thank the following sources for information used in this fact sheet and recommends these sources for additional information on these issues.

The International Ground Source Heat Pump Association (IGSHPA)
http://www.igshpa.okstate.edu/index.htm

The Air-Conditioning and Refrigeration Institute (ARI)
http://www.ari.org/intro.html

National Ground Water Association (NGWA)
www.ngwa.org/pdf/geothermclip.pdf

GEOEXCHANGE – Geothermal Heat Pump Consortium (GHPC)
http://www.geoexchange.org/index.htm

EPA - Underground Injection Control (UIC) Program
http://www.epa.gov/safewater/uic.html

UIC Program Wyoming DEQ
http://deq.state.wy.us/wqd/groundwater/uicprogram/index.asp

UIC Program Wisconsin DNR
http://deq.state.wy.us/wqd/groundwater/uicprogram/index.asp

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UIC/DW Program Kansas DHE
www.kdheks.gov/geo

UIC Program Oregon DEQ
www.deq.state.or.us/wq/groundwa/uichome.htm

Groundwater Program New Jersey DEP
http://www.state.nj.us/dep/watersupply/well.htm

UIC/Groundwater Program Delaware DNREC
http://www.dnrec.state.de.us/water2000/Sections/GroundWat/DWRGrndWat.htm

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